Linear Transformers

A linear transformer may also be regarded as one whose flux is proportional to the currents in its windings.

A **transformer** is generally a four-terminal device comprising two (or more) magnetically coupled coils.

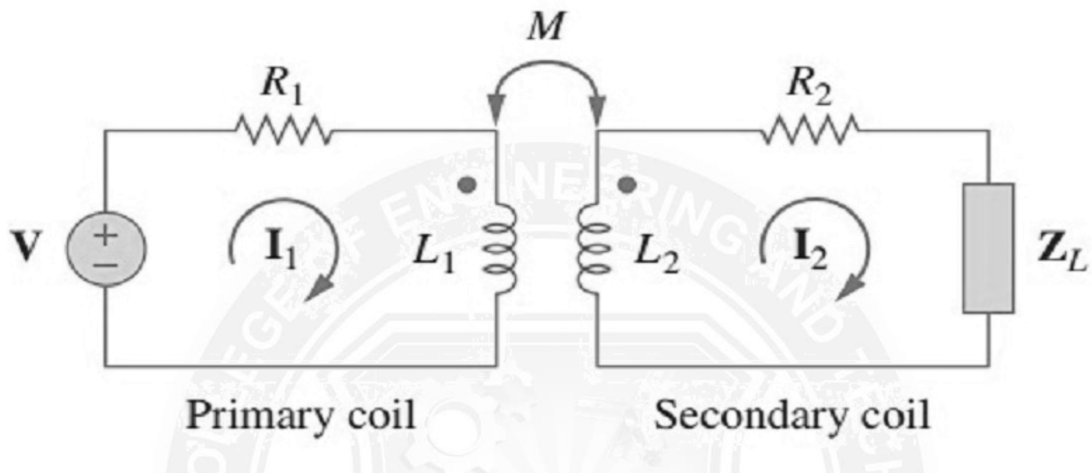

Figure 5.3.1 Linear Transformer

The coil connected to the load is called the secondary winding. The resistances R_1 and R_2 are included to account for the losses (power dissipation) in the coils.

The transformer is said to be linear if the coils are wound on a magnetically linear material—a material for which the magnetic permeability is constant.

Such materials include air, plastic, Bakelite, and wood. In fact, most materials are magnetically linear.

Linear transformers are sometimes called air-core transformers, although not all of them are necessarily air-core.

They are used in radio and TV sets. Figure.(2) portrays different types of transformers.

We would like to obtain the input impedance $\mathbf{Z}_{in}$ as seen from the source because $\mathbf{Z}_{in}$ governs the behaviour of the primary circuit.

Applying KVL to the two meshes in Figure.(1) gives

$$\mathbf{V} = (R_1 + j\omega L_1)\mathbf{I}_1 - j\omega M\mathbf{I}_2$$

$$0 = -j\omega M\mathbf{I}_1 + (R_2 + j\omega L_2 + \mathbf{Z}_L)\mathbf{I}_2$$

$$\mathbf{Z}_{\text{in}} = \frac{\mathbf{V}}{\mathbf{I}_1} = R_1 + j\omega L_1 + \frac{\omega^2 M^2}{R_2 + j\omega L_2 + \mathbf{Z}_L}$$

Notice that the input impedance comprises two terms.

The first term, $(R_1 + j\omega L_1)$, is the primary impedance.

The second term is due to the coupling between the primary and secondary windings.

It is as though this impedance is reflected to the primary. Thus, it is known as the reflected impedance $\mathbf{Z}_R$, and

$$\boxed{\mathbf{Z}_R = \frac{\omega^2 M^2}{R_2 + j\omega L_2 + \mathbf{Z}_L}}$$

It should be noted that the result in Equations.(2) or (3) is not affected by the location of the dots on the transformer, because the same result is produced when M is replaced by $-M$.

For this reason, it is sometimes convenient to replace a magnetically coupled circuit by an equivalent circuit with no magnetic coupling. We want to replace the linear transformer in Figure.(1) by an equivalent T or π circuit, a circuit that would have no mutual inductance. The assumption of a common ground for the two coils is a major restriction of the equivalent circuits. Common ground is imposed on the linear transformer in Figure.(3) in view of the necessity of having a common ground in the equivalent T or π circuit